(NASA-CR-97630) ATM ALTERNATIVE MISSION STUDY, COMMUNICATIONS COVERAGE (Bellcomm, Inc.) 8 p

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BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D. C. 20036

SUBJECT: ATM Alternative Mission Study - Communications Coverage - Case 620

DATE: August 12, 1968

FROM: J. P. Maloy

## ABSTRACT

Alternatives to the AAP baseline Cluster Mission for the ATM are being explored. Communications coverage data on attainable orbital altitudes for 28 and 56 day missions at 28.5°, 50° and 63.5° inclination angles are compared in this memorandum.

During the launch phase and the transitional period between insertion and injection into the elliptical orbit for the alternative missions examined, none has a significant communications coverage advantage. In all cases, two ships may be required to support launch coverage. Again in all cases there is approximately a 75 minute gap after insertion until the first land station contact exceeding 3 minutes. It may be necessary that ARIA (Apollo Range Instrumentation Aircraft) or ship support be provided.

When compared with the present baseline mission only one of the alternative ATM missions (150X600 n.m.) explored exceeds the percent of non-overlapping coverage provided (31.7% vs 27.2% for VHF; 36.6% vs 29.4% for USB). This mission also has no gaps between 5 minute contacts for 28 days exceeding 90 minutes (record capability of ATM tape recorder) compared with 32 gaps for 28 days of the baseline mission. The 150X400 n.m. mission has approximately the same percent of non-overlapping coverage as the baseline mission and significantly fewer 90 minute gaps (9 vs 32).

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# MEMORANDUM FOR FILE

## INTRODUCTION

Several alternative LM-ATM missions are being examined as backup to the AAP Cluster Mission. This memorandum presents the results of a study to identify any additional communication system requirements and to compare the amounts of communication coverage provided by some of the alternative missions with the baseline Cluster Mission. Communications coverage data on attainable orbital altitudes for missions at 28.5°, 50°, and 63.5° inclination angles are compared for the first 28 days out of 56. For these orbits, total solar viewing and continuous solar viewing times are being generated by Bellcomm's Systems Analysis Department in an effort to establish criteria for judging relative scientific yield for these missions.

## PROCEDURE

Three of the possible alternative missions were selected for comparison. These were considered to be significantly different in design to present the extremes for comparison and yet representative of the group. The communications coverage analysis was performed with the aid of computer programs. Basic data for the launch phase was derived from a modification to the BCM-ASP program by Irwin Hirsch, of the Bellcomm AAP Mission Analysis Department. Data for the transition phase (orbital coverage from insertion to injection into the elliptical orbit) and the elliptical orbit coverage for twenty-eight days was provided by the ALTER I program.* All coverage times were calculated for above a 5° elevation angle from the tracking station to the vehicle.

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*"A Computer Program to Compute Space Vehicle Contact Time, Slant Range, and Altitude," H. Pinckernell, December 8, 1964.

LAUNCH PHASE COMMUNICATIONS COVERAGE

The following mission designs were examined for effectiveness of launch phase communications coverage: Three LM/ATM launches, into an 81 x 150 n.m. elliptical orbit; one designed for a 56 day mission in an orbital plane inclined at 50.65° to the equatorial plane and two designed for a 28 day mission, one at 50.63° inclination angle and the other at a 63.60° inclination angle. Ship positions were selected somewhat arbitrarily based on experience gained in a previous study*, to supplement the coverage supplied by the land stations at Cape Kennedy, Grand Bahama Island and Bermuda (see Figure I). No attempt was made to further optimize the ship locations, but they were selected to provide additional coverage from the last land station's contact through three minutes after the orbital insertion point.

It was concluded for the LM/ATM launches that only one ship would be required to supplement land station contacts and would fulfill launch coverage requirements of having continuous coverage throughout the launch period and three minutes of coverage after the insertion point. Keyhole effects were not considered in this study. The South keyhole at Bermuda (BDA) has already been reduced to a 6° half-angle from the nominal 10° ordinarily used in these studies. However, due to the direction of the trajectories considered here, the North keyhole could be a factor in reducing coverage provided by BDA.

The same three types of missions were examined for the launch of the CM-SM which inserts into an elliptical orbit of 81 x 120 n.m. Similar procedures were employed in selecting ship locations and determining the coverage provided by the combination of land and ship stations. Here, due to the lower apogee, longer time of powered flight, and the maneuvers employed during the ascent sequence which prolonged the achievement of insertion, it was concluded that two ships would be needed to meet requirements as stated. Approximately 1/2 minute of coverage after insertion is provided by the one ship positioned as shown in Figure I. A second ship located further along the subvehicle path would be necessary to supplement this coverage.

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*"Coverage for an Uprated Saturn I Provided by the MSFN for a Launch on a 46° Launch Azimuth," J. P. Maloy, September 20, 1968.

If two ships are required to be deployed for the launch of the CM-SM then two ships could be on station for the launch phase of both vehicles, LM and CM-SM, since current plans call for the launch of the LM and the CM-SM to be within four days of each other.

COVERAGE DURING TRANSITION PHASE (from three minutes after insertion to injection into the elliptical orbit)

Once again three mission designs considered typical in accordance with current studies were examined for communications coverage. Insertion points derived from the launch phase portion of this study were selected and used in the ALTER I computer program. Coverage provided by the MSFN including the three 85' antenna stations at Goldstone, Madrid and Canberra for more than four revolutions of an elliptical orbit 81 x 120 n.m. was calculated. A 10° half-angle was used for the keyhole at all stations where applicable.

The results indicate that for each case there is approximately a 75 minute gap between orbital insertion and the time the first land station of the MSFN had a contact greater than 3 minutes with the vehicle. Due to the criticality of this phase of the mission, i.e. determination of successful orbit achievement and spacecraft status, it is probably desirable that coverage be provided in this interim by the placement of a ship in an appropriate location or by the use of ARIA (Apollo Range Instrumentation Aircraft). The remaining portion of this phase is similar for all missions in that there is adequate coverage.

ORBITAL COVERAGE

The comparative effectiveness of communications coverage provided by the MSFN was examined for three of the alternative mission designs for a twenty-eight day orbital period with the aid of the ALTER I computer program. The ones selected (see Table I) were considered to be basically different enough to have an impact on the amount of communications time available. The latitude of perigee, which was assumed to be the injection point, is a function of the orbital inclination and the apogee of the orbit. The longitude of perigee was selected at random since it could initially lie anywhere. Longitude 10°E was used to start this phase of the coverage analysis.

The results were compared against the baseline mission over a twenty-eight day interval (circular orbit at 230 n.m. and an inclination angle of 28.5 degrees). Keyhole affects were factored in using a keyhole half-angle of 10°. The results are tabulated in Table I and indicate among other things that as the apogee increases, the percent coverage provided by the MSFN increases, as might be expected. Two configurations of the ground network were considered. The first was the USB stations which are a network of eleven 30-foot antenna stations and three 85-foot stations. Tananarive was also included here because of its strategic location and its ability to provide limited VHF telemetry support. The other configuration considered was a network in which all stations have a capability to support the VHF telemetry links of the ATM. This configuration has the same eleven 30-foot stations plus Tananarive, but no 85-foot stations. The addition of the 85-foot antenna stations at Goldstone, Madrid and Canberra to the VHF network configuration for additional USB support did not change the number of gaps exceeding 90 minutes (record capability of ATM tape recorder) except in support of the 150/300 n.m. orbit.

When compared with the baseline mission, the 150/600 n.m. orbit mission yields a greater percentage of coverage and exhibits no gaps greater than 90 minutes compared with 32 gaps for both combinations of stations. The 150/400 n.m. orbit mission, as can be seen in Table I, has approximately the same percent of non-overlapping coverage as the baseline mission and significantly fewer 90 minute gaps (9 vs 32). The 150X300 n.m. mission did not compare favorably due to its relatively low apogee and very high inclination angle of 63.5°.

## CONCLUSIONS

Comparison of the various alternative missions during the launch phase and the transition phase indicates that all have similar support requirements. Each may require two ships during the launch phase to fulfill coverage requirements and each may require the use of another ship or ARIA during the initial orbit of the transition phase to insure a safe orbit. The baseline mission with a circular orbit and a launch azimuth of 90° would require only one insertion ship.

This study of relative communication effectiveness indicates that the mission design with a perigee of 150 n.m. and an apogee of 600 n.m. and an inclination of 50° provides the best communications coverage over the twenty-eight day period, when compared to other alternative missions and to the baseline mission. The 150X400 n.m. mission at an inclination angle of 50° compares favorably with the baseline mission in percent of coverage and exhibits a big reduction in the number of gaps of 90 minutes or more.

2034-JPM-dlb

J. P. Maloy

Attachment

## TABLE I

## NETWORK COVERAGE

| ORBIT | | % TIME IN CONTACT | | NUMBER OF GAPS BETWEEN 5 MIN. CONTACTS FOR 28 DAYS EXCEEDING 90 MIN.* | |
|---|---|---|---|---|---|
| ALTITUDE (N.M.) | INCL. ANGLE | VHF | USB | VHF | USB |
| 230 | 28.5° | 27.2% | 29.4% | 32 | 32 |
| 150/300 | 63.5° | 12.4% | 15.9% | 69 | 38 |
| 150/400 | 50° | 20.9% | 27.4% | 9 | 9 |
| 150/600 | 50° | 31.7% | 36.6% | 0 | 0 |

*90 Minutes is the record capability of ATM tape recorder.

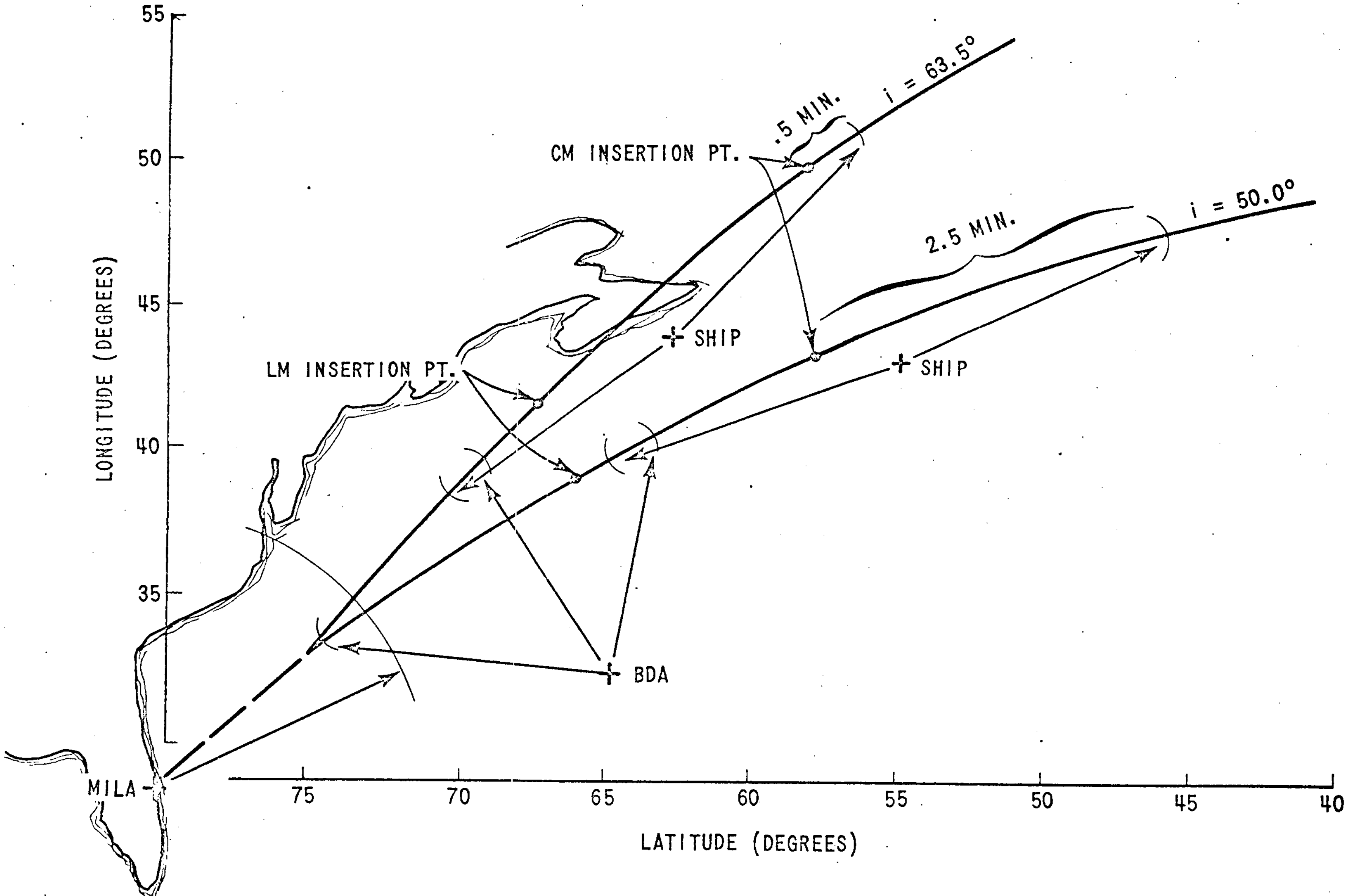


FIGURE 1 - LAUNCH COVERAGE FOR 50° AND 63.5° ORBITAL INCLINATIONS